



## **Mission Assurance in the New Business Environment**

# **Advanced Quality Systems**

### *Short Course*

## **Mission Assurance Up-Front & Built-In**

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### **What are Advanced Quality Systems (AQS)?**

AQS represent the use of systems engineering, business and management practices in a coordinated and integrated way. The Japanese pioneered this concept in the 1950's as "Lean" business principles & practices. The individual pieces have been around forever, ... their integrated use is the novelty, and key to success.

### **Key Concepts of Advanced Quality**

The following paragraphs provide brief narrative discussion of key Advanced Quality concepts.

#### **Integrated Product Development**

The I.D. approach requires the involvement of personnel from a number of functional disciplines (e.g., manufacturing engineering, production operations, quality, tooling design and fabrication, industrial engineering and suppliers) in the design process. In an I.D. approach, design trade studies will explicitly consider quality, tooling and manufacturing factors (e.g., manufacturing technology, fabrication and assembly costs, sources of supply, tolerances, part count, yields and verification methods) to ensure that fully informed decisions affecting these factors are made before significant resources are committed. There are many tools for facilitating IPD. As an example, quality function deployment (QFD) provides a structured, team-oriented planning methodology for translating the top-level customer needs into appropriate requirements at each level of product and process design.

#### **Identification and Control of Key Characteristics**

Key characteristics are the features of a material or part whose variation has a significant influence on product fit, performance, service life, or manufacturability. The principal benefit of identifying key characters is that doing so highlights those manufacturing processes — out of the thousands that can exist in a large factory — which should be the focus of process control and variability reduction efforts.

Statistical process control techniques are used for controlling key characteristics in production.

A number of methodologies exist to facilitate the identification of key characteristics, including analysis of historical data, Failure Modes and Effects Criticality Analysis (FMECA), and Fault Tree Analysis. QFD and design of experiments can also be employed to assist in the identification of key characteristics.

### **“Robust” Design**

A “robust” design results in a product that is insensitive to or tolerant of sources of variation and change that are difficult, costly or impossible to control. These sources (sometimes referred to as “noise”) may include such factors as environmental conditions within a factory, minor variations in raw material, or differences in how individual customers use the product. Robust designs perform as intended despite these noise factors.

A commonly used method to achieve robustness is “parameter design,” in which the optimum parameters of product and process characteristics (e.g., material composition, processing time, pressure, etc.) are determined such that the product is least sensitive to “noise” factors. The selection of these parameters and their settings is accomplished using statistically designed experiments, among which Taguchi fractional factorial experimental designs are perhaps the most widely known.

### **Design to Manufacturing Process Capability**

A design policy that requires new designs to be optimized with respect to manufacturing processes is among the most fundamental AQS design practices. Effective AQSs require that design tolerances be established so that manufacturing process variability falls within these limits. This relationship is measured by process capability indices ( $C_p$ ,  $C_{pk}$ ). AQSs commonly require that, as a minimum, the manufacturing process that control key characteristics must achieve a certain minimum process capability index value.

(This value typically ranges from a  $C_{pk}$  of 1.33 for non-complex mechanical parts to 2.00 for parts used in complex commercial electronic systems that must exhibit extremely high reliability.)

### **Design for Assembly/Manufacturing (DFA/M).**

DFA/M techniques are concerned with the reduction of product cost through design simplification. DFA/M achieves such simplification through parts reduction and by ensuring that the remaining parts are easy to manufacture and assemble.

While not originally intended as a quality improvement technique, DFA/M usually results in significantly enhanced product quality. This is because many nonconformances are not attributable to failure to control manufacturing process variation, but rather to complexity of the product. Defects such as missing or loose fasteners, faulty connections, and incorrectly installed parts all tend to be a function of product complexity. For each fastener or connector eliminated from the design, for example, the opportunity for one of these types of defects to occur is also eliminated.

## **Process Variability Reduction & Control (PVR)**

PVR is a systematic approach for continuously seeking sources of variation within the key product characteristics and process parameters that control those characteristics and then developing means for eliminating the sources. Such means can include additional design robustness, eventually eliminating the applicable characteristics from the list of those considered key, and process improvements.

## **Variation Control Techniques**

After the key product characteristics have been identified, along with the key manufacturing process parameters that control them, basic statistical techniques can be used to ensure the processes are capable and stable (e.g.,  $\bar{X}$ /R charts). Tools that can be used to seek out sources of variation in such processes include the following:

- (1) Process flow charts
- (2) Pareto charts
- (3) Cause and effect (Ishikawa) diagrams
- (4) Design of experiments (DOE) analytical techniques can eliminate or control sources of variation by identifying and addressing the most influential sub-process sources of variation.
- (5) The Poka-Yoke or failsafing technique involves implementation of hardware, software or monitoring instrumentation sufficient to “lock-out” or eliminate process failure modes. The approach is a fundamental defect prevention tool intended to preclude the possibility of process errors that could result in product defects.

## **Other Important Elements of an Advanced Quality System**

- Quality Function Deployment (QFD)
- Geometric Dimensioning and Tolerancing (GD&T)
- Use of stable, capable manufacturing processes as the basis for product acceptance
- Control of variation in the measurement systems, calibration and metrology
- Root cause, closed loop corrective action
- Deployment of advanced quality system elements to suppliers

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